A new use for old coal mines
A potential source of energy from beneath our feet

Did you know that about a quarter of the population of the UK live near or above abandoned coal mines? The last underground coal mine in the UK closed in 2015, but the old mines could continue to provide a source of energy today, without any more coal being extracted. How could this be?

It is well known that in many deeper mines, the miners worked in stifling heat – not from the coal itself, but from the fact that the temperature of the Earth's crust increases by more than 3°C for every 100m depth. This is mainly because of the radioactive decay of elements in the rocks of the mantle beneath, so it is a geothermal process. Once the mines were abandoned, pumps which would have kept them dry were switched off, and water has gradually filled up the old mine levels, heating up as it does so. In many places, this water has to be pumped out and treated to avoid it flooding and polluting streams and rivers. Could the heat which it contains be used to heat our homes and offices?

A settling tank for warm mine water pumped out of workings at the National Coal Mining Museum, near Wakefield, Yorkshire. *(© Copyright Stephen Craven and licensed for reuse under this Creative Commons Licence.)*

The mine water in the photograph is being pumped out at the rate of 30 litres per second and is a constant 13°C. If this were to be piped through a heat pump system it could generate 0.87MW of energy.

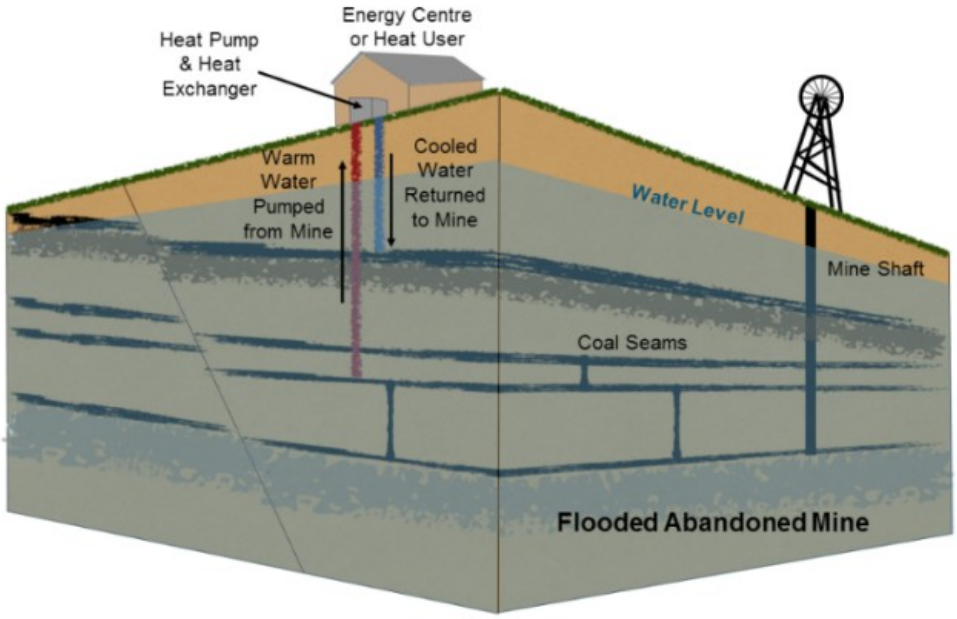


Diagram showing the principle of heat from flooded coal mines. *(Charlotte Adams, Durham Energy Institute).*

There are around 23,000 old coal mines in the UK. It has been estimated that if the heat storage capacity in those mines could be used to release energy, it would, in theory, provide many times more than the equivalent of the total electricity needs of the whole country.

Suggest some of the advantages of using warm water from flooded coal mines in helping to reduce our carbon footprint (*see Context below*).

However, there are many problems too, such as:

- Electricity is needed to pump the water and also to run the heat pumps to raise the temperature for central heating systems and we need to ensure that there is a net gain in energy.
- Boreholes into old mines have to be wide (40cm). Boring equipment might be damaged if it hit old concrete or metal structures in the mine working. The best target might be some of the rocks of the "roof" above the coal workings, which became permeable when they fractured as the coal seams were extracted.
- The quantity of mine water may eventually run out, if the pumping rate exceeds the flooding rate.
- The cooled water which is returned to the mine may not become re-heated quickly enough for this to be sustainable. Its chemical composition

would also have been changed by treatment on the surface, which could cause problems for the rocks and pipework below ground.

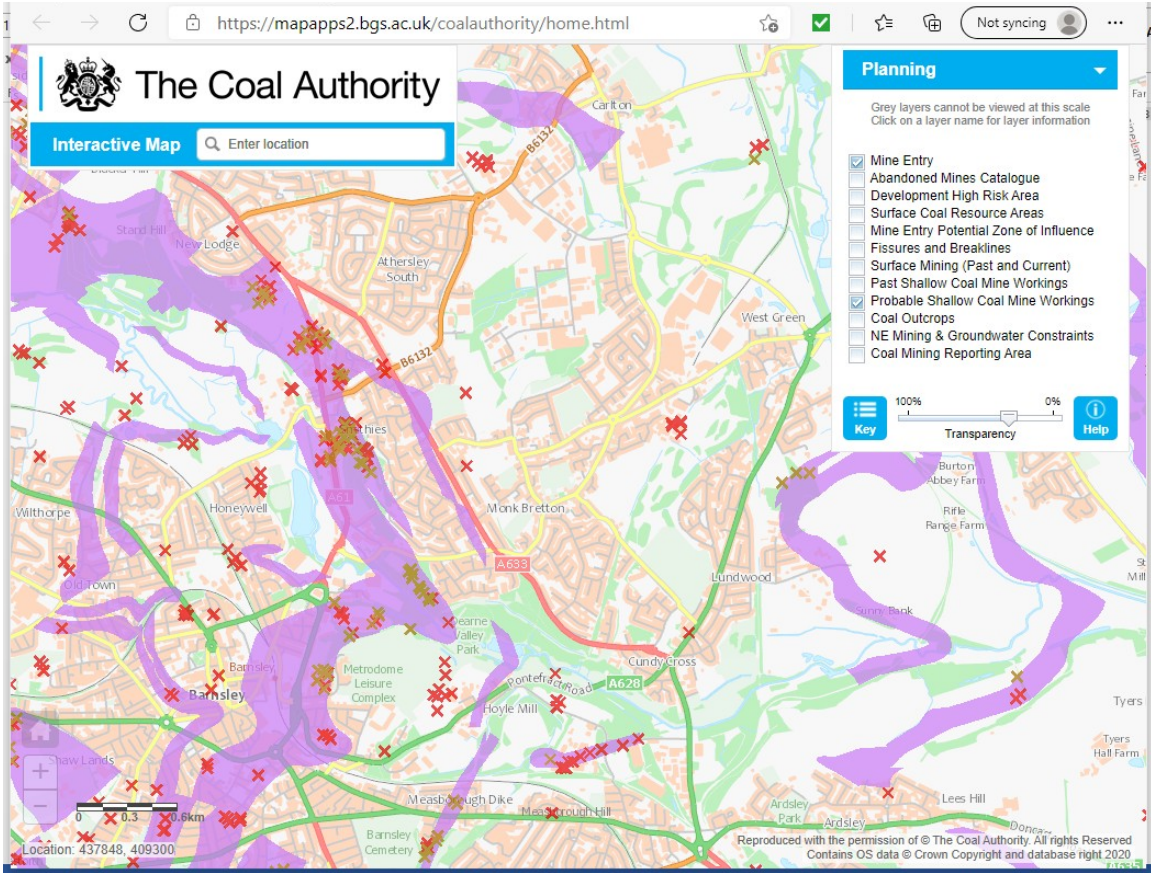
- It may be better to leave it flooded and use a heat exchanger in the mine itself, *as* part of a closed loop, avoiding the very large pumps.
- Collapse of old workings could restrict the rate at which water can flow through the mine.
- Unexpected pathways for mine water in old workings may bring it out a few miles away from its source.
- As the photograph of the settling tank shows, mine water contains dissolved salts and acids, which may corrode or clog up the pumps and the heat exchangers.
- Methane may be released as old workings are pumped out. If this escapes it would add a greenhouse gas to the atmosphere. Recovery of the methane may be possible but might not be economically viable.

In spite of such problems, planning is going ahead in old coalfield regions, under the UK Government's £320 million Heat Network Investment Programme. One such proposal is to heat the buildings in a new development at Seaham Garden Village in County Durham. The development will consist of 750 affordable homes, 750 private homes, a school, shops, and medical and innovation centres. Since this is very close to an existing plant where warm (20°C) mine water is treated, having been pumped up from several hundred metres below, this would save on the electricity required for pumping to heat the buildings.

The proposed Seaham Garden Village development. (*Coal Authority*).

If you live in a former coal mining area anywhere in the world, could a heat recovery system be installed to provide a low-carbon source of energy to your community? If you live in the UK, use the Coal Authority's interactive map at Interactive Map Viewer | Coal Authority (bgs.ac.uk) to investigate the extent of the coal mines beneath your feet and to see where the main shafts were. The map has a range of electronic layers which can be added or subtracted.

If you do not live on an old coalfield yourself, you can choose an area from the map and find out about it in the same way.



A screen print from the Coal Authority's interactive map for the intensively mined Barnsley area in South Yorkshire

The back up

Title: A new use for old coal mines.

Subtitle: A potential source of energy from beneath our feet.

Topic: Investigating how geothermal heat in flooded coal mines might be used to heat our homes and workplaces.

Age range of pupils: 14 years upwards

Time needed to complete activity: 30 minutes, plus time for local investigations via the internet or visits.

Pupil learning outcomes: Pupils can:
- explain the origin of the heat in flooded coal mines;
- investigate the potential for mine water energy in their local area or in another chosen location;
- evaluate the advantages and disadvantages of mine water as a heat source;
- strengthen their awareness of the need for low-carbon energy sources.

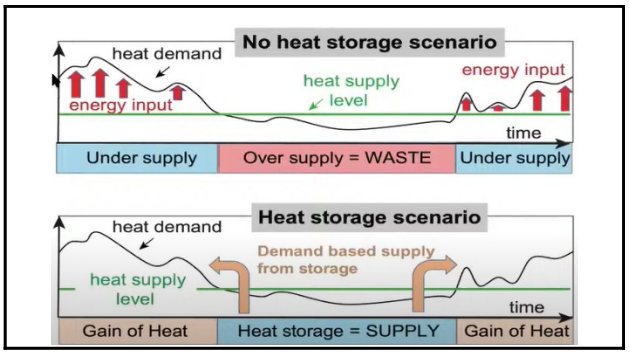
Context: Government 'net-zero' targets will affect many areas across the world. This Earthlearningidea explores how energy might be derived from warm mine water for local use.

(*Advantages of using warm water from flooded coal mines in helping to reduce our carbon footprint include:*
- *Heating derived from mine water is low-carbon, (but not carbon-free because the water has to be further warmed using a heat pump, which operates like a fridge in reverse and needs electricity to run it).*
- *It can provide local heating without the need for transporting energy long distances.*
- *It is a beneficial side effect of the remediation of polluted mine water.*

- *A high proportion of the population of the UK lives above former coal mines).*

To find out if your local area is suitable for energy from warm mine water you could use local geological maps and, if you live in the UK, the interactive map from the Coal Authority to evaluate the possibilities;

Following up the activity: The rock surrounding the flooded mine is a good insulator. So another possible use for flooded mines is for them to be used as a store of extra heat, at times when surplus heat is being generated from surface activity. An example is "waste" heat from the essential cooling of large computer centres, which could be used to heat up the mine water in the summer and then used to enhance the work of the heat exchangers in the winter. This would enable the energy supply to be evened out, as shown in the diagram.



How the energy supply could be evened out with the use of mine water as a heat store (Nick Shaw Policyleeds@leeds.ac.uk)

Investigate your own area to see if such a heat source, where there is a summer excess of heat, might be used in this way.

Underlying principles:
- Temperature increases with depth below ground at between 30° and 35°C per kilometre.
- Water which has accumulated in old mine workings becomes more heated with depth.
- The warm mine water can be used in heat pumps similar to ground source heat pumps, run by electricity from the national grid, to provide hot water for central heating systems.
- The thermal power (in Watts) which can be generated from mine water is proportional to the flow rate of the water and its temperature.
- Local potential impacts can be explored and evaluated.

Thinking skill development: Understanding the principle of heat extraction from heated mine water involves construction skills, and possibly cognitive conflict. Discussion of the merits or drawbacks of such schemes involves metacognition and applying the principles to the local area is a bridging skill.

Useful links:
https://www2.groundstability.com/geothermal-energy-from-abandoned-coal-mines/
https://energypost.eu/36bn-gwh-the-limitless-geothermal-from-old-uk-coal-mines/
https://www.bgs.ac.uk/news/uks-new-underground-observatory-open-for-research/
Search for 'net-zero' on the Earthlearningidea website to find other Earthlearningideas relating to climate change mitigation or adaptation, as in the table on the last page.

Resource list:
- paper copies or a screen version of this activity;
- local topographic map and where possible, geological map;
- a view from the window, or photographs of the local area.

Source: Written by Peter Kennett of the Earthlearningidea Team, with thanks to John Hunter for technical advice.

This information was as accurate as possible in spring 2021.

The 'How will the 'net-zero' target affect your local area?' series of Earthlearningideas

Topic			Earthlearningidea title
Introduction			How will the 'net-zero' target affect your local area?
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wave	Harnessing the power of waves
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear power - harnessing the energy of the atom
		Nuclear waste	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		'Blue' hydrogen	Blue hydrogen: the fuel of the future? *Also:* Hydrogen of many colours
		Geothermal – hot rocks	Deep geothermal power from 'hot dry rocks': an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		'Green' hydrogen	Green hydrogen used to even out renewable energy supplies? *Also* Hydrogen of many colours
		Hydro – storage	Matching supply and demand using stored water
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let's plant some trees
Possible adaptation measures		Coastal flooding	How will rising sea level affect our coastlines?
		Inland flooding	Inland flooding: a Sheffield case study
		Landslides	Landslide danger
		Agriculture	The future for global agriculture